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FLIGHT CREW TRAINING PLAN

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
Houston, Texas

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FLIGHT CREW TRAINING PLAN

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1.0 INTRODUCTION

The training program described in this document covers the training plan from February 1964, to the development of specific mission training. It encompasses the training for manning both the Gemini and Apollo space flights for the full complement of NASA flight crew personnel. At this time, the Gemini Project is defined to the point that the training program can be planned in detail. Since the Apollo Project is in its early stages of development, only the early training is defined.

In consideration of the number of flight crews to be trained and the limited lead time available on training equipment, the training program has been formalized to accomplish the required training. Because flight dates are paced by various rates of subsystem development, the training plan must also have flexibility. In this regard, the plan has been sectionalized to simplify the revisions that will be necessary to update the plan and to define the Apollo training in later stages of the project.

2.0 TRAINING REQUIREMENTS

The flight crew training plan has been formulated to meet certain criteria or training requirements. These general training requirements, as described in the following paragraphs, insure spacecraft crews capable of accomplishing the space flight mission under all conditions within the limits of the spacecraft, launch vehicle systems, and man.

2.1 Scientific and Technical Background Training.- Provide scientific and technical competency to: (a) understand the principles of operation of the complex spacecraft systems; (b) engage in the evaluation and development of the spacecraft and launch vehicle to assure its compatibility with manned space flight operations; and (c) understand and perform scientific space experiments.

2.2 Environmental Familiarization.- Provide familirization with the unique environmental conditions of space flight to minimize their possible effect on crew performance.

2.3 Contingency Training.- Provide capability to survive without injury in those contingency situations for which training will eliminate or minimize possible hazards.

2.4 Systems Training.-

2.4.1 Spacecraft: Provide thorough knowledge of the design, operation, and inflight maintenance capability of all the systems.

2.4.2 Launch Vehicle: Provide familiarity with the design of the systems and thorough knowledge of malfunction monitoring and abort design features.

2.5 Mission Training.-

2.5.1 Spacecraft Control: Provide ability to manually or semi-manually control the spacecraft in all attitudes, and translation maneuvers within the prescribed mission.

2.5.2 Systems Monitoring and Management: Provide knowledge and ability to monitor the systems for normal operation, to control the systems and to make efficient use of the consumables on board for the accomplishment of the mission objectives.

2.5.3 Systems Malfunction Detection and Correction: Provide knowledge and ability to recognize abnormal system operation in the booster and the spacecraft, make failure analysis from indications, and take corrective action which could include an aborted mission or an early reentry during any phase of the mission.

3.0 TRAINING PROGRAM

The Training Phasing Chart (chart 1, section 4.0) is provided to indicate the overall chronological phasing of the training for the preparation of the flight crews for crew assignment to the first manned flights of the projects. The Gemini training for the command and senior astronauts and the astronauts is staggered due to the required time to train the new group. This staggering of the Gemini mission training eliminates the unrealistic trainer time utilization required for preparing the total group simultaneously for the first flights.

The training program is discussed in detail in this section under three major headings: General, Gemini and Apollo training.

3.1 General Training.- The training areas that fall under the general heading are those that apply to both projects. These areas are Science and Technology Summary Courses, Operations Familiarization, Environmental Familiarization, Contingency Training, Spacecraft and Launch Vehicle Design and Development and Aircraft Flight Program.

3.1.1 Science and Technology Summary Courses: The Space Science and Technology courses were chosen to fulfill the specific requirements as designated in section 2.0. They are oriented to bring the flight crews to a common level of understanding on the subjects. The majority of these courses are basic in nature with two of them dealing directly with spacecraft systems - Gemini Onboard Computer and Apollo Guidance and Navigation. However, a basic digital computer course is given prior to the specific Gemini computer course and the basic material of inertial guidance systems is covered in conjunction with the Apollo Guidance and Navigation. With a limited amount of training time available, all of the courses are aligned to presenting that portion of the material under the subject title that is pertinent to the work of the flight crews within the projects and missions. Each course is defined in outline form in the Appendix.

A detailed schedule for the academic program is given in section 4.0. On a weekly basis the courses are scheduled on Monday, Tuesday, and Wednesday for sixteen hours of instruction. The remainder of the week, during this period of academic training, is devoted to project briefings, systems training, operations familiarization, course field trips, physical fitness, and aircraft flying.

The Science and Space Technology courses are listed below with the number of hours of instruction:

	Course	Hours Instruction
*	Geology	58
**	Flight Mechanics	40
**	Digital Computers	12
*	Gemini Onboard Computer	24
	Rocket Propulsion Systems	12
	Aerodynamics	8
	Astronomy	15
*	Guidance & Navigation	34
	Communications	8
	Physics of the Upper Atmosphere and Space	12
	Medical Aspects of Space Flight	12
	Meteorology	4
	Total	239

*All Flight Crews will participate.

**Refresher courses for command and senior flight crews — participate when possible.

Further instruction in geology after the designated 58 hour course will be scheduled on a frequent basis to prepare the flight crews for exploration of the lunar surface. The general content of the follow-on program in geology is also indicated in the Appendix.

3.1.2 Operations Familiarization: The flight crews will be familiarized with the operational support required for spaceflight. The following briefings and tours of facilities will be conducted:

1. Gemini Prelaunch Activities (Cape Kennedy) -

   Overall prelaunch activities briefing

   Tour and briefing on spacecraft and astronaut prelaunch activities (hangar S)

   Tour of complex 19 and briefing on launch operation

   Briefing at Gemini Control Center on operations and equipment including launch vehicle guidance

   Briefing at central control on operation and equipment

2. Apollo Prelaunch Activities (Cape) - Tour and briefing at Saturn launch complex on launch operation

3. Integrated Mission Control Center - Briefing on Equipment and Operation

4. Recovery Operations Briefing

3.1.3 Environmental Familiarization: The areas of the mission environment in which the flight crews will be familiarized are acceleration, weightlessness, lunar gravity, vibration and noise, and pressure suit environment.

1. Acceleration - The acceleration familiarization is one of the objectives of the centrifuge programs. The purpose of this training is to minimize possible pilot performance degradation because of accelerations. The second Gemini centrifuge training program is planned to be conducted shortly before the first manned Gemini flights. This program will familiarize the flight crews with launch, selected launch aborts and reentry acceleration profiles. A similar centrifuge training program is planned for the

Apollo program. The centrifuge programs are discussed in detail in the Gemini and Apollo training portions of this paper.

2. Weightlessness and Lunar Gravity - By means of a modified KC-135 to fly at zero gravity for approximately 30 seconds per parabolic trajectory the flight crews will be exposed to weightlessness. In the same manner the crews will be exposed to lunar gravity ($\frac{1}{6}$ "g"). Each pilot will receive two flights in the KC-135 with each flight containing 18-20 parabolas. Three pilots can be accommodated on a flight. Therefore, the training will require ten flights (two flights per day for five days) to complete the training for the fourteen astronauts. The 6570th Aerospace Medical Research Laboratories, Wright Patterson Air Force Base, will support and conduct this training.

   Within the two KC-135 flights the flight crews will accomplish the following activities:

   a. Torque board (small plywood panel with handles on both sides).

   b. Soaring and tumbling.

   c. Self-rotation

   d. Free-float sensations

   e. Eating and drinking

   f. Hand tool maintenance (untethered)

   g. Hand tool maintenance (tethered)

   h. Single-impulse mass ejection

   i. Tumble and spin recovery

   j. Self maneuvering unit flight

   k. Fluid dynamics demonstration

   l. Coriolis effect demonstration

   m. Walking behavior under lunar gravity

the proper use and care of the survival equipment, and the use of the parachute in the construction of clothing, shelters and signals. The field training will be conducted in an area considered representative of many of the world's desert regions. As in the tropic survival field training the teams of two pilots each will spend two days at remote sites practicing desert survival techniques in practical training.

c. Water Survival - The one-half day academic portion of the water survival training will be given by Dr. D. Stullken of the Recovery Operations Division. Dr. Stullken's lecture will cover the following topics: requirements for human survival; food and water requirements and sources at sea; progressive aspects of survival; effects of drinking sea water.

For the practical experience in water survival one day of activities is scheduled at the Water Safety and Survival School, Naval School of Preflight, Pensacola, Florida. They will conduct the following training in their enclosed tank without and with the pressure suits: basic swimming strokes; underwater escape from a cockpit; life raft boarding; parachute water landing; helicopter rescue by sling and seat; parachute drag escape; parachute engulfment and shroudline entanglement.

The survival equipment will also be exercised during the water egress training.

2. Ejection Seat Training - Each pilot will receive two rides on the Gemini ejection seat tower at the Air Crew Equipment Laboratory, Philadelphia Naval Base, Pennsylvania. The purpose of this training is to familiarize the crew with the seat operation, build their confidence in using the seat and obtain ejection slump measurements for each pilot for adjusting the C.G. of the Gemini seat for the actual flights. The two rides, one at 8 "g's" and 1 at 12 "g's" at approximately 250 "g's" per second onset rate, will be completed for three pilots each day of operation.

The slump data is recorded by cameras and the seat acceleration data is telemetered from the seat and presented on an oscillograph recorder. The data obtained will be extrapolated to the design limits of the Gemini ejection seat of 22 "g's" at 250 "g's" per second onset rate by correlating this data with the data received from the test program completed in July 1963.

3. Parachute Training - To prepare the flight crews for the contingency situation of using the personal parachute during a space flight mission, instruction in parachuting will be given the pilots. The course has been designed to train the flight crews in the areas of parachute landing, parachute maneuvering to avoid ground obstacles and parachute drag after landing. By far the majority of non-fatal injuries that occur in parachuting are attributed to these three areas. An area of concern on high altitude ejection is free fall, which will be covered by a comprehensive briefing. Since the use of the personal parachute could occur over land or water, the training considers both contingencies.

   The parachute training will be conducted on a very low risk basis by the use of the Para-Commander parachute built by the Pioneer Parachute Company. The safety of this parachute is inherent in its method of operation which also makes it particularly suited for training. This parachute is an ascending parachute when towed behind a vehicle with a long tow line. The distinct advantages of this canopy are: the jumper has a fully inflated and stable canopy before leaving the ground; and, the rate of descent can be controlled by the towing velocity to increase the landing velocity in increments from a light to a free descent landing.

   The following paragraphs outline each phase of the training as they will be accomplished:

   a. Parachute Landing Fall - Ground School - Four Hours - This training will consist of demonstrations, instruction, and supervised practice in "prepare-to-land" position, touchdown, roll procedures and canopy securing. Initial training will be on the ground, the second phase from a raised platform.

   b. Launch Procedure - 15 minutes - This training is particular to the ascension canopy and is conducted at the time of the first flight on the parachute. This training will consist of equipment checkout and launch procedure.

c. Parachute Landing Fall - Towed Flight and Landing - One and one-half per man - This phase is supervised training in actual parachute landings. Each pilot will make five towed parachute landings ranging from light to normal parachute impact.

d. Canopy Manipulation - Ground School - One-half hour - Ground training will be conducted in parachute slip and turn control by riser manipulation.

e. Canopy Manipulation - Free Descent - One hour per man - This phase consists of supervised training in actual canopy manipulation. Each pilot will make three free descents in which programed turns and slips will be executed. The training will be accomplished by towing the trainee to altitude and releasing the tow line to provide free descent.

f. Parachute Water Landing - (Ground School) - Four hours - This phase consists of demonstration, instruction and supervised practice in water impact and harness and equipment release.

g. Parachute Water Landing - Towed Flight and Landing - One hour per man - Supervised training in actual water landings will be conducted with each pilot making three descents into the water and completing water landing procedures.

h. Free Fall Technique - Four Hour briefing - A briefing on the techniques of free fall stabilization and maneuvering will conclude the parachute training program.

3.1.5 <u>Spacecraft and Launch Vehicle Design and Development</u>: The pilots will participate in and contribute to spacecraft and launch vehicle design and development, by means of the activities listed below:

1. Participate in spacecraft and launch vehicle engineering and mock-up reviews.

2. Participate in specific contractor and MSC design and development studies and simulations.

3. Attend the various internal and contractor meetings which are of concern to the pilots.

4. Participate in pressure suit and personal equipment development.

5. Follow project ground test programs.

6. Follow development of preflight test program of spacecraft.

3.1.6 Aircraft Flight Program: Spacecraft flight readiness will be maintained through the use of T-33, F-102, and T-38 type aircraft assigned to MSC and based at Ellington Air Force Base.

A two week course in flying helicopters will be provided the pilots by the Naval School of Preflight, Pensacola, Florida, with a continuing program conducted at Ellington Air Force Base. The helicopter flying will prepare the flight crews for further simulations of the lunar landing.

3.2 Gemini Training.-

3.2.1 Project Briefings and Systems Training: This training will familiarize the flight crews with the total Gemini Project starting with a description of the mission to be performed and progressing to the launch vehicle systems, the spacecraft systems and crew station.

1. Mission Profiles - The following Gemini mission considerations will be presented to the pilots over a two day period:

   Movie - "Gemini Project"

   Mission Objectives

   Launch Schedule

   Spacecraft Description - Configuration and Modular Design

   Gemini; Agena Mission Phases

      Launch Window Constraints
      Rendezvous Trajectories and Techniques
      Entry - primary and backup procedures

2. Launch Vehicle Briefing - The launch vehicle briefing will be conducted by the Martin Marietta Corporation over a two day period at the Manned Spacecraft Center. The briefing is of sixteen hours duration and is presented in

two phases. Phase I is devoted to discussion of all airborne systems to a functional block diagram analysis level including systems interface. Phase II consists of discussions of vehicle and subsystems flight characteristics directly affecting manned flight.

Phase I - Airborne Systems (Day 1) -

LV Familiarization - The basic structure, weights, and other physical characteristics of the launch vehicle. Also, major modifications made to the Titan II in conversion to the Gemini launch vehicle.

LV Electrical System - Power sources, distribution and the flight sequencing functions of the electrical system.

Propulsion and Propellant Systems - A functional analysis of engine operation, of the major engine components, characteristics of the propulsion system, the propellants, their feed, monitoring, temperature conditioning, and physical characteristics.

Guidance and Controls - Functional loop analysis of the flight controls and the MOD III G Radio Guidance Systems, block diagram discussions of the primary and secondary flight control system, a flow and component analysis of the hydraulic system, the guidance/control interface and basic flight sequencing.

Malfunction Detection System - Detection philosophy and basic system operation.

Range Safety and Ordnance Systems - The philosophy of and components used by the range safety and ordnance systems.

Instrumentation System - Airborne telemetry system, major vehicle parameters to be monitored, block diagram analysis of the monitoring equipment.

AGE Philosophy and Countdown Techniques - Type of equipment used in checkout and launch of the vehicle and analysis of the countdown activities.

Phase II - Vehicle Parameters and Performance (Day 2) -

Flight Dynamics - Analysis of launch vehicle parameters.

Guidance and Controls - The parameters of control and guidance - both open and closed loop.

Propulsion System - System performance characteristics; effects of attitude, propellant conditioning, effect of vibration on vehicle performance and changes being made to eliminate these vibrations.

Failure Modes and Abort Studies - Malfunction events and their resulting effect upon vehicle behavior and pilot escape, the relative probability of malfunctions by subsystem and steps taken to assure maximum astronaut survival.

3. Spacecraft Systems Briefings and System Trainer Operation - A 30-hour set of briefings extending over one week on the Gemini spacecraft systems will be presented to the flight crews. These lectures are operationally and sequentially oriented and will utilize the Gemini Systems Trainers extensively. In order to provide the class with a background in cockpit layout, an introduction to controls and displays will be given by Crew Station Branch before the systems lectures. Courses will be presented by qualified MAC instructors who will detail the normal modes of system operation, the alternate modes, and the functional relationships of components and subsystems. The instructors will be assisted by systems experts from the various engineering departments of MAC who will supply the design philosophies and backgrounds of each system. The schedule for the Gemini spacecraft systems briefings is:

Monday - Controls and Displays, Attitude and Maneuver Control System

Tuesday - Attitude and Maneuver Control System

Wednesday - Electrical Power Generation and Distribution, Sequential System

Thrusday - Environmental Control System, Propulsion Systems

Friday - Instrumentation, Communications

4. Crew Station - In the systems briefings the systems controls and displays will be discussed system by system without the total crew station being available. Therefore, the pilots will spend some time in the Gemini Mission Simulator to become familiar with the total crew station geometry. At this time engineers from the Flight Crew Support Division will be on hand to discuss the crew station with the individual pilots and answer their respective questions.

3.2.2 Part Task Training: The Gemini Part Task Training will prepare the crews for and supplement the mission simulator training in the retrofire reentry control tasks. The trainer has the capability of providing the retrofire and reentry control tasks in the rate command and direct control modes. Retrofire capabilities consist of variable thrust alinement, variable firing sequence, and failure of one or more retrorockets to fire. Four reentry profiles have been preprogramed: a constant lift trajectory, two roll modulated trajectories for correcting down range and cross range errors, and a zero lift trajectory. Approximately ten hours training per pilot will be completed, which will be dependent on the individual's needs.

The Farrand Visual Display System is being modified to provide a visual docking simulation of the Agena target in conjunction with a star background with a range capability of 50 nautical miles to docking. Although it is basically a research tool, it will also be a valuable supplement to the docking and Gemini mission trainers for night rendezvous at an earlier date than the GMS external display system. Each pilot will be scheduled for several sessions on this simulator.

3.2.3 Launch Vehicle Abort Training: The launch abort training will accomplished on the Ling-Temco-Vought moving base simulator to provide a high fidelity simulation including the kinesthetic cues of a wide variety of Gemini normal and malfunction launch trajectories.

In the simulation the launch abort instrumentation of the left hand portion of the Gemini panel will duplicate the spacecraft panel with the indicator lights, accelerometer, flight director attitude indicator, analog tank pressure gauges, and the event timer. The launch vehicle controls will also be duplicated from the spacecraft.

The categories of training runs to be simulated are:

1. Normal launch or variation of limits of normal launch

2. Engine failures - partial or total loss of thrust

3. Sequential failures

4. Pressurization and propellant failures

5. Guidance failures

6. Spacecraft and instrument failures

7. Ordnance and electrical failures

8. Double failures

One week prior to the start of the simulation all the flight crews participating will receive a thorough briefing at MSC on the abort situations to be simulated, the cockpit indications of the impending failure and interpretation of these indications, the action to be taken and the ground rules for the launch abort simulation. At that time a briefing package of the launch vehicle characteristics and their mechanization in the simulator will be distributed.

The training on the simulator will consist of six two-hour sessions which will result in approximately 150 runs. Two pilots will alternate between sessions to receive two sessions a day for three consecutive days. Before the first session a short review briefing will be held at the contractor's plant to review the ground rules, simulator limitations and answer questions. The first day of running will be familiarization runs which will familiarize the pilots to the different types of failure situations. Approximately 50 familiarization runs will be completed. These runs will be quickened where possible by starting the run just prior to the initiation of the effect of the malfunction. During the familiarization runs the malfunction to be simulated will be discussed before and after each run. For the four remaining sessions the malfunctions will be programed at random to include variations of the normal launch.

The number of runs of a particular type will be determined by its difficulty to successfully abort and the probability of the malfunction.

3.2.4 Egress Training: The Gemini Egress Training Program consists of four training sessions plus full scale recovery training for the specific mission crew and backup crew thirty days prior to flight date.

Session One will be held at the Spacecraft Flotation Tank, Ellington Air Force Base. Training will consist of briefing on sink rate, sink attitude, underwater egress techniques, and a film on underwater escapes from boilerplate spacecraft. Two astronauts will be scheduled per session.

Session Two will also be conducted at the Flotation Tank. Training will consist of E.C.S. operation, personal equipment operation, and familiarization with flotation characteristics, and surface egress techniques and practice.

Session Three will be aboard the spacecraft handling ship "Retriever" in Galveston Bay or the Gulf of Mexico. Training will consist of demonstration of flotation characteristics on the open water, possible flooding effects, surface egress practice, and use of Gemini survival gear.

Session Four will also be aboard the spacecraft handling ship "Retriever" in the Gulf or Bay. Training will consist of practicing preimpact and impact procedures, operation of radios, and E.C.S. equipment, snorkel and cabin vent valve operation, flotation collar, and shipboard egress.

Refresher training for each specific mission crew and backup crew will be held in open water near Cape Kennedy, Florida, during the full scale recovery exercises approximately 30 days prior to each flight.

Portions of the Egress Training Program may be modified at a later date as a result of the test/evaluation/development program managed by Recovery Operations Division. Participation of the Flight Crew Support Division and Flight Crews is required during the test evaluation phase to assure proper continuity and development of preliminary operating procedures to be further developed and perfected by all flight personnel during the egress training program.

EGRESS TRAINING OUTLINE

Session 1	Three hours (Boilerplate 201) Flotation Tank, EAFB 1. Review Test film 2. Four underwater egresses 3. Briefing
Session 2	Two hours (Static Article 5) Flotation Tank, EAFB 1. Egress checklist 2. Personal equipment operation 3. E.C.S. operation 4. Surface egress practice
Session 3	Two hours (Boilerplate 201) Galveston Bay 1. Flotation characteristics 2. Flooding effects 3. Surface egress 4. Life raft
Session 4	Three hours (Static Article 5) Galveston Bay 1. Preimpact checklist 2. Impact 3. Radio, E.C.S., snorkel operation 4. Flotation collar 5. Shipboard egress
Refresher Training	Six hours (Static Article 5) Open water Florida 1. Recovery briefing 2. Review egress films 3. Preimpact checklist 4. Impact 5. E.C.S. operation 6. Radio operation 7. Personal equipment operation 8. Flotation characteristics 9. Surface egress 10. Life rafts 11. Helicopter pick-up 12. Flotation collar 13. Shipboard egress

3.2.5 Centrifuge Training: A second Gemini centrifuge program will be accomplished at the Aviation Medical Acceleration Laboratory, NADC, Johnsville, Pennsylvania, (See chart IV, section 4.0). The objectives of the program are: familiarization with Gemini accelerations profiles and control task training during reentry accelerations for the new crew personnel and refresher training in the Gemini acceleration profiles for the assigned Gemini crews.

The Gemini I centrifuge fixture (updated) will be used for the program. The simulation will be similar to the Gemini I program, that is, launch is open loop and reentry profiles generated from modified six degree-of-freedom equations of motion with altitude time rate of change preprogramed. Each pilot will accomplish the following runs:

1. Normal launch and reentry with half down range reentry profile.

2. Normal launch and reentry with zero lift reentry profile.

3. Normal launch and reentry with intermediate down range reentry profile.

4. Launch abort and associated reentry. Abort prior to staging due to engine failure.

5. Launch abort and associated reentry. Abort at T + 150 seconds simulating second stage ignition failure.

3.2.6 General Mission Training: The mission training phase of the Gemini training will provide the crews with training in both normal and abnormal spacecraft and spacecraft systems operation. The Gemini mission simulator supplemented by the systems trainers, briefings and the docking trainer will be used to provide this training.

The mission training is divided into four phases: familiarization, system failure training, general mission training with random malfunctions and docking training. A brief description of each phase is as follows:

1. Familiarization - The purpose of this phase of the mission training program is to thoroughly indoctrinate crew members with Gemini spacecraft systems and their normal operation throughout an entire "normal" mission profile. Since the visual display system will not be available until

later, all control will be done on instruments. Implementation of this phase is as follows:

Systems Trainers - A thorough review of the systems and their normal operation will be conducted prior to the crew's participation on the GMS. This review will emphasize system operation during typical orbital and rendezvous missions. These briefings will be operationally oriented and as detailed as possible.

Gemini Mission Simulator (14 hours) - Each pilot will complete seven familiarization sessions of approximately two hours each on the Gemini Mission Simulator, five of which will be in the left seat and two in the right seat.

Familiarization Sessions -

Session No. 1 - Left Seat - Attitude and maneuvering control practice using the various control modes. Included in this session will be retrofire attitude control and platform alignment procedures.

Session No. 2 - Left Seat and Session No. 3 - Right seat Typical launch (through insertion and initial platform alignment) and reentries (from final platform alignment to impact). Insertion parameters such as velocity correction required by pilot to obtain nominal orbit and impact points on the reentry footprint will be varied.

Session No. 4 - Left Seat - Three orbit mission.

Session No. 5 - Left Seat, and Session 6 - Right seat, Typical rendezvous and catch-up maneuvers.

Session No. 7 - Left Seat - Normal mission with rendezvous at first apogee.

2. System Failure Training - The purpose of this phase of the mission training is to thoroughly prepare the flight crews in system failure detection analysis, correction, and/or alternate procedures. Failures primarily dependent upon criticality of mission success and secondarily upon probability of occurrence will be emphasized. This phase of the program will require approximately ten weeks. Generally, the first day of each week will be utilized to cover a particular system on the system trainers or by briefings attended by all crew members. The remaining four days of each week will consist of the application of

this information by individual crew members on the mission simulator.

A brief outline of this phase of training is given below.

SYSTEMS FAILURE TRAINING

Systems	Sessions: Systems Trainers	GMS: Left Seat	GMS: Right Seat
Electrical Sequential*	1	2 (No. 8, 9)	
Electrical Power	1		1 (No. 10)
ACME	1	1 (No. 11)	
OAMS	1	1 (No. 12)	
RCS	1	1 (No. 13)	
Combined ACME, OAMS & RCS		1 (No. 14)	
Navigation and Control (IMU, Radar, FDI, Time Reference System, Computer, Horizon Sensors)	Briefing	1 (No. 15)	1 (No. 16)
ECS	1		1 (No. 17)**
Comm. and Instrumentation (DCS, Telemetry, Voice, Beacons)	Briefing		1 (No. 18)
Total Sessions	8	7	4
Approximate Hours	20	14	8

*During the second session on the GMS on Electrical Sequential (left seat) the Electrical Power is covered in the right seat.

**In Pressure Suit.

3. Mission Training with Random Malfunctions (24 Hours) - This phase consists of 12 sessions per pilot on the GMS of which 8 sessions/pilot will be in left seat and 4 sessions/pilot in the right seat. A preselected list of

random malfunctions will be programed for each session. Usually these malfunctions will not require an aborted or early termination of the mission, however, one session will concentrate on launch abort problems. The sessions will be divided as follows:

Session 19 - Left Seat, and Session 20 - Right Seat - Three orbit mission.

Session 21 - Left Seat - Three orbit mission.

Session 22 - Left Seat, and Session 23 - Right Seat - Launch Abort problems.

Session 24 - Left Seat - Three orbit mission (in pressure suit).

Session 25 - Left Seat, and Session 26 - Right Seat - Rendezvous mission with rendezvous at first apogee.

Session 27 - Left Seat, and Session 28 - Right Seat - Rendezvous mission utilizing slow catch-up procedure

Session 29 - Left Seat - Same as Session 25

Session 30 - Left Seat - Same as Session 26

4. Translation and Docking Training - The program utilizing the MSC docking trainer, consists of eight sessions of approximately two and one-half hours each. In addition each pilot will occupy the right seat during Session No. 1. Normally twelve runs will be made per session half of which will be made with no scheduled failures. A typical docking maneuver includes the following operations, (starting from various initial conditions and closure rates); alignment of spacecraft with the Agena, maneuver into docking cone, engagement, latch-on, rigidize, docking tasks, unlatch, maneuver out of docking cone.

Session 1 will be a familiarization session with six nominal runs and six non-nominal runs. The non-nominal runs are for demonstration purposes. Four runs will be made in each mode of operation. Failures will be demonstrated and corrective action taken by the pilot. One pilot will ride as observer in the right seat while the pilot in the left seat controls attitude translation.

Session 2 will consist of practice in Rate Command Mode with six nominal and six non-nominal runs scheduled. All control is from left seat with one pilot onboard.

Session 3 will consist of practice in Pulse Mode with six nominal and six non-nominal runs scheduled with one pilot onboard. All control is from the left seat.

Session 4 will consist of practice in Direct Mode with six nominal and six non-nominal runs. One pilot onboard. Control is from the left seat.

Session 5 will consist of task sharing between the left and right seat positions. The pilot in the left seat will control translation and the pilot in the right seat will control attitude. Two runs will be made in each of the three modes of operation. Each pilot will make six runs in each seat. No malfunctions are scheduled.

Session 6 consists of task sharing utilizing the Rate Command Control Mode. Six runs will be nominal and six runs will include non-nominal run conditions. Each pilot will make six runs in each seat.

Session 7 is a task sharing utilizing the Rate Command Control Mode. Six runs will be nominal and six runs will be non-nominal. Each pilot will make six runs in each seat.

Session 8 consists of task sharing utilizing the "direct" control mode during six nominal and six non-nominal runs. Each pilot will make six runs in each seat.

Approximately sixteen failures may be simulated on the trainer with up to four failures occurring at any one time. Only thirteen failures can be simulated for which the pilot may take corrective action and continue the rendezvous. Three failures can be simulated which would probably require abort of the rendezvous, namely - OR LOGIC roll, OR LOGIC yaw, and maneuver malfunctions. Corrective action which may be accomplished by the pilots consists of switching ACME Logic from PRImary and SECondary, switching gyros from PRImary to SECondary, switching ATTITUDE CONTROL MODE, switching ATTITUDE DRIVERS or MANEUVER DRIVERS to SECondary. A failure analysis for the translation and docking trainer is included in the appendix.

Failures to be simulated are as follows:

1. OAMS ATTITUDE DRIVERS
2. OAMS MANEUVER DRIVERS
3. OR LOGIC ROLL
4. OR LOGIC YAW
5. COMMUNICATIONS L. SEAT TO R. SEAT
6. COMMUNICATIONS R. SEAT TO L. SEAT
7. DIRECT MODE
8. PULSE MODE
9. RATE COMMAND MODE
10. RATE GYRO - ROLL
11. RATE GYRO - PITCH
12. RATE GYRO - YAW
13. ACME LOGIC - ROLL
14. ACME LOGIC - PITCH
15. ACME LOGIC - YAW
16. MANEUVER MALFUNCTIONS

Outlines of the sessions as well as possible failures are shown below. Specific failures on a run to run basis will be detailed shortly prior to commencement of this training and at a time when simulation requirements can be better assessed.

TRANSLATION AND DOCKING TRAINING OUTLINE

Session	Mode	Pilotage	Runs
1	ALL	Left seat (right seat occupied)	12
2	RATE COMMAND	Left seat	12
3	PULSE	Left seat	12
4	DIRECT	Left seat	12
5	ALL	Both seats	12
6	RATE COMMAND	Both seats	12
7	PULSE	Both seats	12
8	DIRECT	Both seats	12

3.3 Apollo Training

3.3.1 Project Briefings: This training will familiarize the flight crews with the Apollo mission and the present state of development of the spacecraft and launch vehicle.

1. Mission Profiles - The following Apollo mission considerations will be presented to the pilots over a two day period:

   Movie - "Apollo Project"

   Launch Schedules

   General Launch Vehicle Description - S-1B, S-V

   General Spacecraft Description (Command, Service and Lunar Excursion Modules)

   Lunar Landing Mission Profile

      Earth Orbit
      Translunar
      Lunar
      Transearth
      Entry and Landing
      Abort Considerations

3.3.2 Launch Vehicle Briefing: The Marshall Space Flight Center, Huntsville, Alabama, will give the flight crews a briefing on the S-1B and S-V launch vehicles and their systems and a tour of MSFC's facilities.

3.3.3 Systems Familiarization Briefings: A series of familiarization briefings on Apollo CM/SM and LEM spacecraft systems will be given the flight crews. These briefings are intended to provide background knowledge in systems operation to facilitate the overall mission study. The various systems to be covered include: Guidance and Navigation, Stabilization and Control, Reaction Control, Spacecraft Propulsion, Power Generation and Distribution, Sequential Circuits, Environmental Control, Communication and Instrumentation.

4.0 SCHEDULING CHARTS

CHART I.- TRAINING PHASING

Phase I - Scientific and Space Technology Courses, Project Familiarization and Flight Operations Briefings

Phase II - Environmental Familiarization, Control Task, Spacecraft Egress, LEM Ingress and Contingency Training

Phase III - Mission Training: Systems Launch Vehicle Abort and Full Mission Training

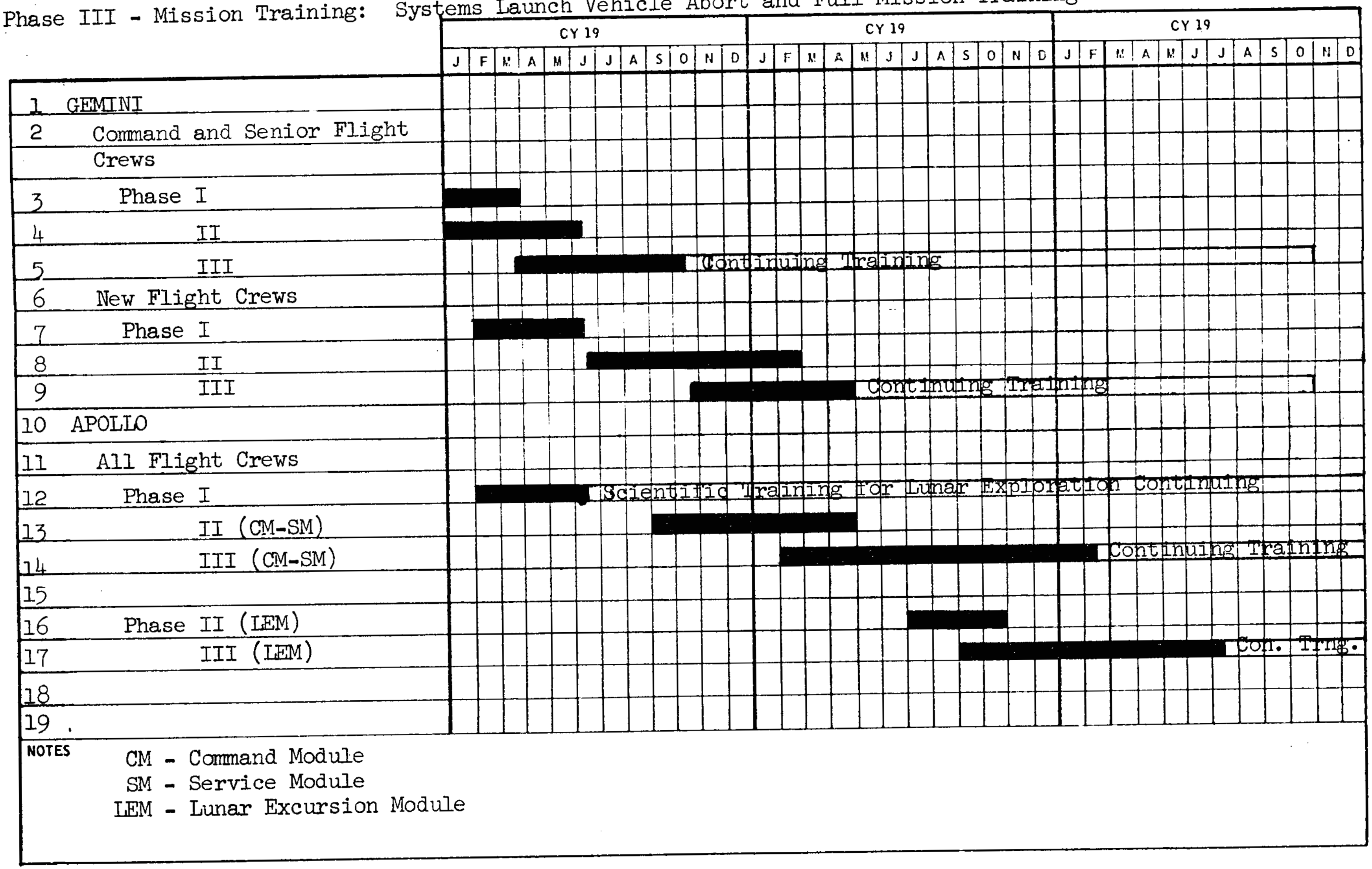


CHART II.- CREW TRAINING EQUIPMENT SCHEDULE

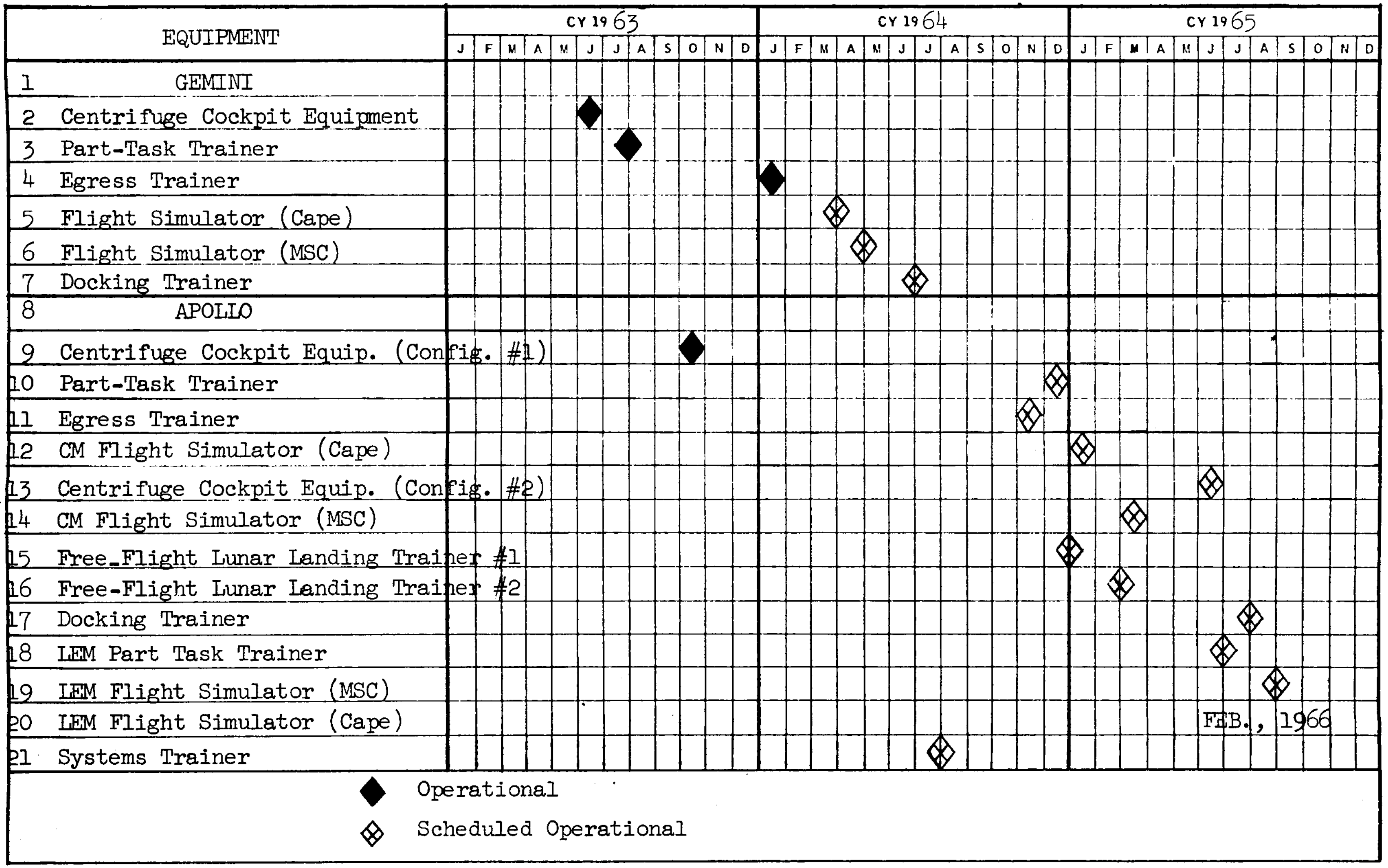
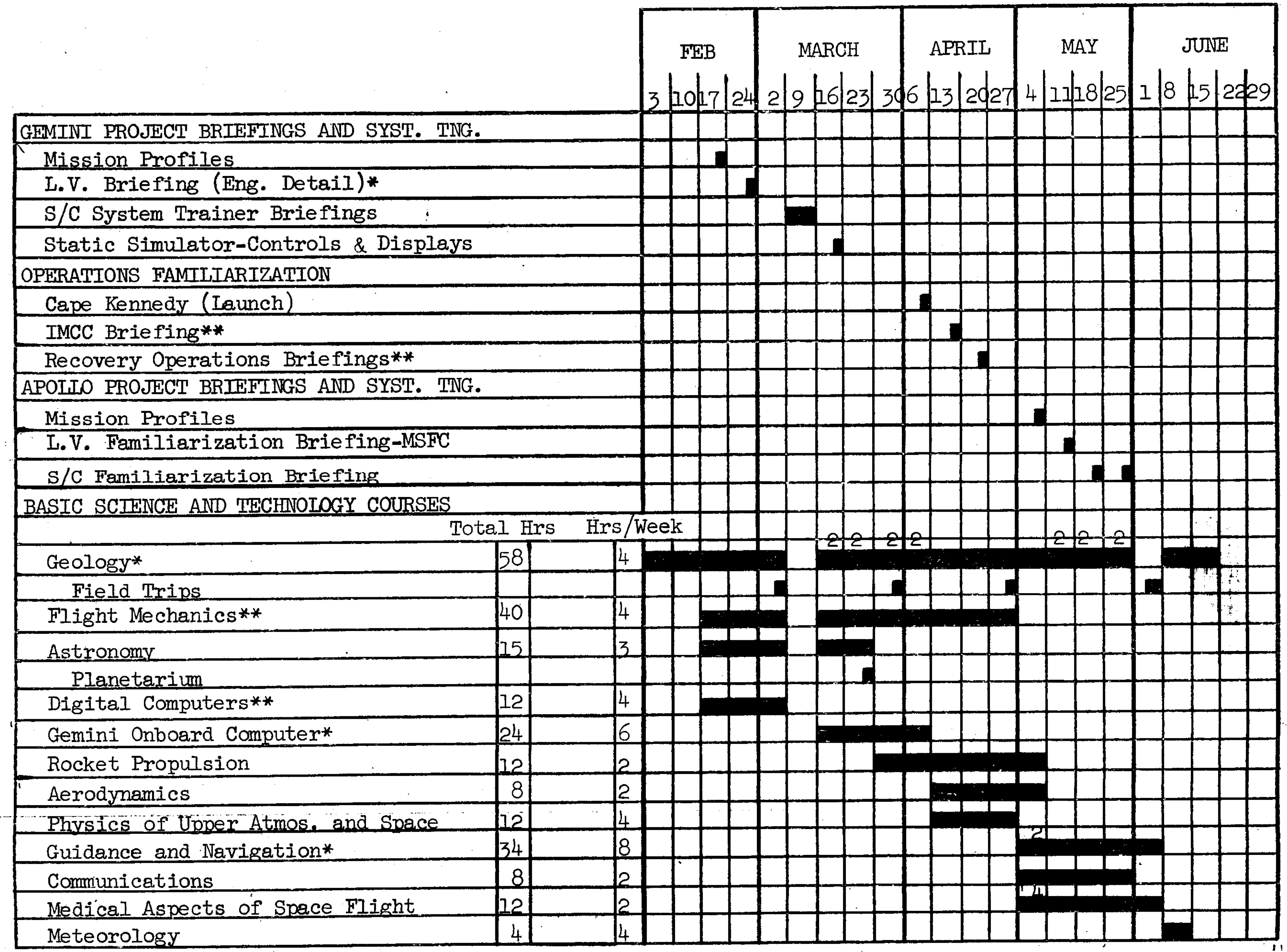


CHART III.- ACADEMIC TRAINING SCHEDULE

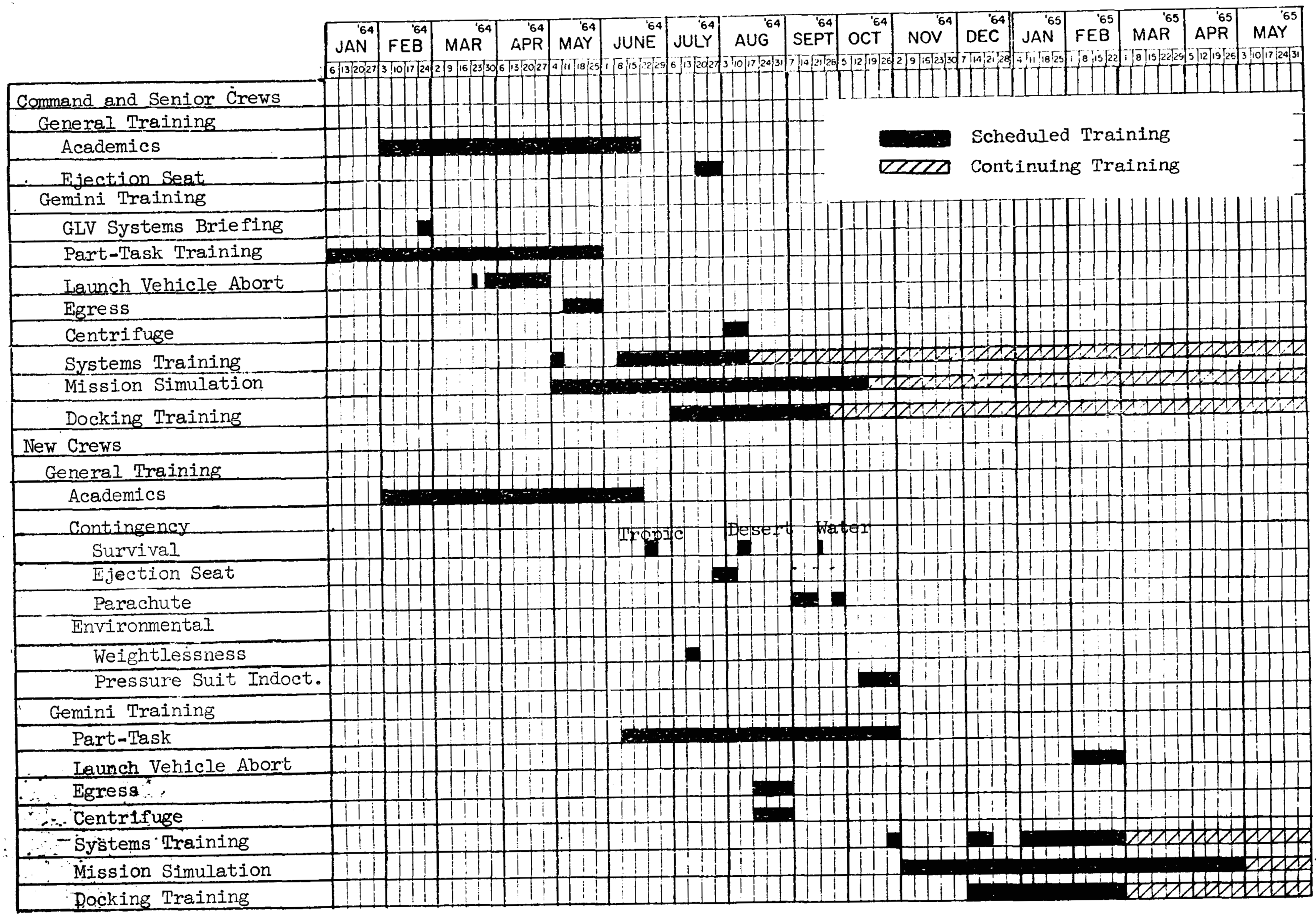
CHART III.- ACADEMIC TRAINING SCHEDULE



*All astronauts participate

** Command and Senior crews participate when possible for refresher

CHART IV.- OVERALL TRAINING SCHEDULE



Docking Training

5.0 APPENDIX

APPENDIX

OUTLINE OF SCIENCE AND TECHNOLOGY COURSES

Course	Time (Hours)	Instructor
GEOLOGY (Terrestrial and Lunar)	58	Dr. Dale Jackson, U.S. Geological Survey, Uel Clanton, Advanced Spacecraft Technology Div., MSC
FLIGHT MECHANICS	40	Dave Lang, Flight Crew Support Div., MSC
ASTRONOMY	15	Dr. I. J. Prouse, Univ. of Texas
DIGITAL COMPUTERS	12	Dr. Robert Smith, Texas A & M Univ.
GEMINI ONBOARD COMPUTER	24	IBM and McDonnell Aircraft Corporation
ROCKET PROPULSION SYSTEMS	12	C. Yodzis, Propulsion and Energy Systems Div., MSC
AERODYNAMICS	8	Paul Kramer, Flight Crew Support Div., MSC
PHYSICS OF THE UPPER ATMOSPHERE AND SPACE	12	Lunar and Planetary Laboratory, Tucson, Arizona
GUIDANCE AND NAVIGATION	34	MIT and AC Spark Plug
COMMUNICATIONS	8	J. Painter, Ground Support Project Office
MEDICAL ASPECTS OF SPACE FLIGHT	12	Dr. C. Berry, Center Medical Operations Office, MSC
GLOBAL METEOROLOGY	4	Kenneth Nagler, U.S. Weather Bureau

GEOLOGY (58 HOURS)

TERRESTRIAL AND LUNAR (29 HOURS)

1. GEOLOGIC PROCESSES

   a. Terrestrial processes

   b. Lunar processes - comparisons with Earth

2. UNIFORMITARIANISM

3. GEOLOGIC PRINCIPLES

   a. Axioms involving time and space

   b. Geologic space

   c. Geologic time

   d. Concept of geologic history

4. STRATIGRAPHY

   a. General principles - Earth and Moon

   b. Properties of terrestrial stratrified rocks

   c. Probable properties of lunar stratified rocks

   FIELD TRIP: Field relations of stratified rocks

5. STRUCTURE AND LANDFORMS OF EARTH

   a. General principles

   b. Surface expressions of structural processes

   c. Structures and landforms produced by crustal movement

   d. Structures and landforms of igneous intrusions

   e. Structures and landforms produced by igneous extrusions

   f. Structures and landforms resulting from denudation and sedimentation

g. Terrestrial sedimentary features

h. Structures and landforms of impact phenomena

i. Landforms on an earth with no atmosphere

6. STRUCTURE AND LANDFORMS: MOON

a. Relations between structure and landforms on the lunar surface

b. Impact features

c. The maria

FIELD TRIP: Surface expression of structural features

d. Structures and landforms produced by crustal movements

e. Structures and landforms produced by igneous activity

f. Structures and landforms caused by denudation

g. Role of the astronaut-observer in describing small scale structures

7. GEOLOGIC MAPPING

a. Introduction

b. Terrestrial maps

c. Lunar maps

FIELD TRIP: Telescopic observation of the lunar surface

8. GEOPHYSICAL PROPERTIES OF THE EARTH AND MOON

a. Models of the Earth and Moon

b. Terrestrial materials

c. Lunar materials

d. Geophysical measurements

e. Geophysical mapping

9. ENGINEERING APPLICATIONS OF GEOLOGY AND GEOPHYSICS

   a. Properties of terrestrial materials

   b. Properties of lunar materials

   c. Engineering geologic and terrain maps

10. REVIEW

    FIELD TRIP: Geologic Mapping

INTRODUCTION TO MINERALOGY

AND

PETROLOGY (29 Hours)

1. INTRODUCTION
    a. Mineralogy and Crystallography
    b. Origin, occurrence, et cetera, of minerals
2. PHYSICAL PROPERTIES
3. CRYSTAL CHEMISTRY
4. IGNEOUS PETROLOGY (THEORY)
5. CLASSIFICATION OF IGNEOUS ROCKS
6. PLUTONIC IGNEOUS ROCKS
7. HYPABYSSAL IGNEOUS ROCKS AND PEGMATITIES
8. VOLCANIC PETROLOGY (THEORY)
9. VOLCANIC ROCKS
    a. Non-clastic
    b. Pyroclastic
10. SEDIMENTARY ROCKS
11. METAMORPHIC ROCKS
12. TEKTITES AND METEORITES

5-6

GEOLOGY FOLLOW-ON PROGRAM

(To be conducted prior to lunar mission)

SERIES II

- Terrestrial and Lunar Volcanology
- Impact Geology
- Advanced Mineralogy and Petrology

SERIES III

- Geology of the Lunar Surface
- Lunar Applications of Engineering Geology
- Theory and Practice of Exploration Geophysics

SERIES IV AND V

- Studies of Fragmental Rocks
- Theory and Practice of Rock Sampling
- Advanced Field Techniques
- Recent Advances in Lunar Geology

SERIES VI

- Operational Aspects of Lunar Exploration for Mission Planning

FLIGHT MECHANICS (40 Hours)

1. MATHEMATICS REFRESHER

    a. Vector calculus

    b. Matrix algebra

2. BASIC PARTICLE MECHANICS

    a. Newton's Law for a single particle

    b. Angular momentum theorem for a single particle

    c. Energy theorem for a single particle

    d. General central force field problem

        (1) Properties of motion

        (2) Inverse square central force field

            (a) Determination of characteristic motions

            (b) Various specific aspects and relations pertaining to orbital motion

3. MECHANICS OF A SYSTEM OF PARTICLES

    a. Newton's Law

        (1) Linear momentum theorem

        (2) Angular momentum theorem

    b. Classical two-body problem

        (1) Determination of relative motions

        (2) Determination of inertial motions

    c. The classical three-body problem

    d. The classical N-body problem

4. APPLICATION OF PARTICLE MECHANICS TO SPECIFIC FLIGHT SITUATIONS

a. Boost dynamics

(1) Equations of motion simulating the boost phase of space vehicles

(2) Design criteria for boost trajectories

b. Orbital transfer and rendezvous

(1) Equations of motion describing general orbital transfer

(2) Various equations describing the relative motion at terminal rendezvous and docking

(3) Energy considerations

c. Reentry Dynamics

(1) Equations of motion for simulating the reentry of a body with roll modulated lift (including ballistic reentry)

(2) Reentry from near satellite and super satellite velocities

d. Mechanics of Earth-Moon Flight

(1) Restricted three-body problem

(a) General equations of motion

(b) Further restrictions implied by application to Earth-Moon system

(c) Characteristics of Earth-Moon motion

(2) Approximate solutions to Earth-Moon trajectories

(3) Major perturbations which degrade the accuracy of restricted three-body problem solutions

ASTRONOMY (15 Hours)

1. PANORAMIC VIEW OF THE VISIBLE AND KNOWN PART OF THE UNIVERSE
2. CELESTIAL COORDINATE SYSTEMS
3. CONSTELLATIONS
4. ORIENTATION OF PLANETS
5. STELLAR MAGNITUDES
6. EARTH AS AN ASTRONOMICAL BODY
    a. Dimensions
    b. Mass
    c. Triangulation
    d. Principle of determination
7. PROOF OF SPHERICITY, ROTATION, AND REVOLUTION
8. PRECESSION AND NUTATION
9. A SPHERICAL TRIGONOMETRY PROBLEM
10. TIME
    a. Intervals of time
    b. Time at any instant
    c. Standard and zone time
    d. Transformation to another type of time
11. LIGHT
    a. Velocity, reflection, refraction, and dispersions
    b. Electromagnetic radiation and Planck's radiation curve
    c. Atmospheric absorption and transmission of light

12. MOON

    a. Lunar statistics

    b. Sidereal and synodic months

    c. Motion and phases of the moon

13. SOLAR SYSTEM

    a. Distances of planets from sun - Bode's Law

    b. Revolution of planets

    c. Positions of planets relative to sun and earth

14. PLANETS AND THEIR SATELLITES

15. COMETS

16. STARS AND STELLAR CHARACTERISTICS

17. POPULATION OF THE MILKY WAY

DIGITAL COMPUTERS (12 Hours)

1. PROBLEM SOLVING PROCEDURE
2. TOPICS TO BE COVERED
3. NUMBER SYSTEMS
    a. Decimal
    b. Binary
4. COMPUTER LOGIC
    a. Building Blocks
    b. Boolean Algebra
    c. Half Adder
    d. Full Adder
5. COMPUTER FORM
    a. Form
    b. Input-Output Devices
    c. Arithmetic
    d. Memory
    e. Logic
    f. Buffering
    g. Trapping
6. STORED PROGRAM
    a. Instructions
    b. Constants
    c. Data
    d. Instruction Arithmetic

7. PROBLEM SOLVING

    a. Statement of Problem

    b. Numerical Analysis

    c. Flow Chart

    d. Code

    e. Debug

    f. Run

8. PROGRAMING METHODS

    a. Machine Language

    b. Assembly Programs

    c. Compilers

9. FORTRAN

    a. Arithmetic Statement

    b. Declarative Statement

    c. Conditional Statement

    d. Do Statement

    e. Input-Output Statement

10. SUB-ROUTINES

    a. Linkage

    b. Uses

11. MONITOR

    a. Concept

    b. Compilation

    c. Execution

    d. Loader

12. REAL TIME COMPUTING

    a. Input

    b. Interrupt

    c. Priority

    d. Control

    e. Override

    f. Output

13. DATA TRANSMISSION

GEMINI ONBOARD COMPUTER (24 Hours)

1. DIGITAL COMPUTER (IBM)

    a. Characteristics

        (1) Memory

        (2) Arithmetic

        (3) Clock rates

        (4) Inputs/Outputs

    b. Central Computer Information Flow Diagram Analysis

    c. Input-Output Instructions

        (1) Clear and load discretes (CLD)

        (2) Process input or output data (PRO)

    d. Computer Interface Diagram Analysis

        (1) Emphasis on MDIU/DCS Control

        (2) Analysis of data inputs from radar, horizon sensor, and IGS

        (3) Display outputs to attitude display group and IVI

        (4) Miscellaneous interface

            (a) Time reference system

            (b) Launch vehicle

            (c) Data acquisition system

    e. Functional Block Diagram Analysis

        (1) Prelaunch mode

            (a) Computer loading/interface

            (b) Executor and prelaunch routines

(2) Ascent mode

(a) Backup guidance function

(b) Abort check

(c) Orbital insertion

(d) Launch vehicle interface

(3) Catch-up mode

(a) Function

(b) IGS interface

(c) IVI interface

(4) Rendezvous mode

(a) Radar interface

(1) Range data

(2) Angle data

(b) IVI interface

(5) Touchdown predict

(a) Function

(b) Operational procedures

(1) Normal

(2) Override and re-initiate

(3) When time to retrofire is less than 512 seconds

(6) Reentry mode

(a) Operational procedures

(b) Time to retro sequence

(c) Down-range and cross-range error computations

(d) Roll rate command

(7) Correlation between computer modes and FDI presentation

f. Malfunction Detection

(1) Probable causes

(2) Astronaut's corrective action

(3) Malfunction detection circuit analysis

2. OPERATIONAL SEQUENCE (MAC)

a. Prelaunch

(1) Computer loading

(2) Countdown procedures

(3) Platform alignment

(4) Equipment checkout

(5) Targeting

b. Ascent

(1) Lift-off discrete

(2) Roll sequence

(3) Pitch program

(4) Velocity updates

(5) Staging

(6) Pitch steering

(7) Yaw steering

(8) Switch-over smoothing

(9) Sustainer cut-off

(10) Post-separation velocity correction

c. Orbit Control

(1) Power down

(2) Attitude control

(3) IGS power up

(4) IMU alignment

d. Catch UP

(1) Ground commands

(a) Voice

(b) DCS

(2) IVI inputs

(3) Maneuvering control

e. Rendezvous

(1) Radar acquisition

(2) Data collection

(3) Maneuver estimates

(4) Initial maneuver

(5) Intermediate maneuvers

(6) Braking maneuver

(7) Agena commands

f. Retrograde Prediction

(1) Ground updates

(2) Touchdown prediction

(3) Mapping

(4) Reentry initialization

g. Reentry

(1) Retrograde control

(2) Gain changes at separation

(3) Post-retro control

(4) Navigation

(5) Range prediction

(6) Bank angle control

(7) Flight director bias

(8) Full lift at 80 K

(9) Fuel jettison

ROCKET PROPULSION SYSTEMS (12 Hours)

1. PHYSICS OF ROCKET PROPULSION

    a. Equations defining stage performance

    b. Theoretical optimization of stages

    c. Trajectory losses

    d. Rocket engine performance

    e. Solid propellant grain design

2. ABLATIVE MATERIAL CHAMBERS

    a. Materials and fabrication techniques

    b. Chamber and nozzle form

    c. Ablative design considerations

3. THRUST CHAMBER DESIGN CONSIDERATIONS - COMBUSTION INSTABILITY

4. INJECTOR DESIGN

5. PROPELLANT PRESSURIZATION SYSTEMS

6. PROPELLANT SYSTEMS

AERODYNAMICS (8 Hours)

1. NEWTONIAN FLOW THEORY, INCLUDING GEMINI AND APOLLO

2. REENTRY CONFIGURATIONS

3. REENTRY PERFORMANCE

   a. Entry corridor

   b. Footprint

   c. Lift modulation

4. SPACECRAFT HEATING

   a. Causes

   b. Heating environment

   c. Heat protection

5. LAUNCH VEHICLE AERODYNAMICS

   a. Wind induced oscillation on launch pad

   b. Typical launch aerodynamic time history

   c. Pressure distribution and wind profiles

PHYSICS OF THE UPPER ATMOSPHERE AND SPACE

1. SOLAR ACTIVITY; ELECTRON DENSITY OF THE INTERPLANETARY MEDIUM; RADIATION BELTS OF THE EARTH

2. AURORAE AND AIRGLOW

3. PARTICLES IN THE INTERPLANETARY MEDIUM AND EARTH'S UPPER ATMOSPHERE; ZODIACAL LIGHT; COUNTERGLOW; METEORS AND METEORITES

4. THE EARTH"S UPPER ATMOSPHERE - EXOSPHERE AND IONOSPHERE

5. CHEMICAL REACTIONS IN THE UPPER ATMOSPHERE; THE OZONOSPHERE

6. TIDES AND CIRCULATIONS IN THE UPPER ATMOSPHERE

APOLLO GUIDANCE AND NAVIGATION (34 Hours)

1. APOLLO NAVIGATION TECHNIQUE (MIT)
2. INTRODUCTION OF G & N SYSTEM
3. G & N SYSTEM DESCRIPTION
4. G & N SYSTEM OPERATIONS
    a. Preflight checkout and alignment
    b. IMU alignment
    c. Optical measurements
    d. Attitude control of spacecraft
    e. Velocity correction
5. INERTIAL SUBSYSTEM MECHANIZATIONS
    a. IMU structure
    b. Navigation base
    c. Axes
    d. Temperature control
    e. Stabilization loops
    f. Gyro caging
    g. Accelerometer loops
    h. Coupling display units
    i. Modes of operation
    j. Power supplies
    k. Display and control panels
    l. Signal monitoring and detection
    m. Power and servo assembly

6. OPTICAL SUBSYSTEM MECHANIZATION

   a. Telescope

   b. Sextant

   c. Modes of operation

   d. Integrating and positioning loops

   e. Power supplies

   f. Display and control panels

7. COMPUTER SUBSYSTEM ORGANIZATION

COMMUNICATIONS (8 Hours)

1. BASIC COMMUNICATIONS CONCEPTS

    a. Energy Propagation

    b. Noise

    c. Frequency spectra

    d. Modulation

    e. Antenna Theory

2. RADIO RANGING (RADAR)

    a. Basic types

    b. Theory

3. RADIO TELEMETRY

    a. Multiplexing

4. GEMINI TELECOMMUNICATIONS SYSTEM (Spacecraft and Ground System)

    a. Description

    b. Limitations

5. APOLLO TELECOMMUNICATIONS SYSTEMS (Spacecraft and Ground System)

    a. Modified Gemini System

    b. Deep Space System

    c. Performance Considerations

    d. Limitations

MEDICAL ASPECTS OF SPACE FLIGHT (12 Hours)

1. INTRODUCTION; NORMAL ENVIRONMENTAL ENVELOPE
2. THEORY OF HOMEOSTATIC MECHANISMS
3. RESPIRATION AND CARDIOLOGY
4. NORMAL PHYSIOLOGY AND PHYSIOLOGY AS ALTERED BY SPACE ENVIRONMENT
5. PHYSIOLOGY OF VISION AND EAR, NOSE, AND THROAT.
6. DISORIENTATION AND VERTIGO
7. NEUROMUSCULAR AND SKELETAL SYSTEM
8. G. I. SYSTEM AND NUTRITION
9. URINARY SYSTEM AND FLUID BALANCE
10. ACCELERATION AND WEIGHTLESSNESS
11. VIBRATION
12. RADIATION
13. BIOINSTRUMENTATION - PRESENT AND FUTURE

GLOBAL METERÓROLOGY (4 Hours)

1. METEOROLOGICAL CONDITIONS AFFECTING SPACE FLIGHT OPERATIONS

2. WEATHER AS OBSERVED FROM ABOVE

    a. Weather systems

    b. Observations on interest to meteorology